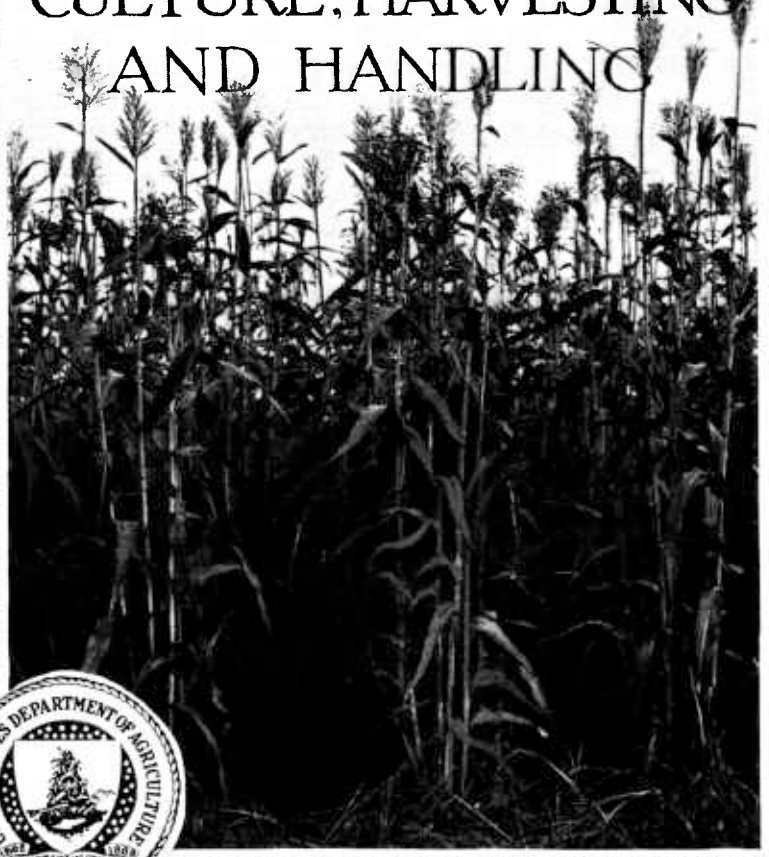
U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1619

SORGO FOR SIRUP PRODUCTION

CULTURE, HARVESTING AND HANDLING



THE PRODUCTION OF SORGO for sirup making extends from the Gulf States to Wisconsin and Minnesota, 35 or 40 States ordinarily being included in the area in which the crop is cultivated for this purpose. The region of the greatest production is in the Southern States.

As a source of sirup, sorgo is most commonly grown to supply home needs, and the area cultivated on individual farms averages less than an acre in size; but there are a few commercial factories, and to supply these the crop is grown in extended fields, usually under contract.

Production varies from year to year. A high point of 49,505,000 gallons of sorgo sirup, having an average value to the producer of $1.069 a gallon, was reached in 1920, production being stimulated at that time by a scarcity of sugar following the World War. Following this there was a decline in production. In 1925 approximately 24,926,000 gallons were produced, with an average price of 94.9 cents a gallon received by the producer. In 1928 production was approximately 26,972,000 gallons, the average price received by the producer being 91.5 cents a gallon.

The sirup is used for both table and culinary purposes. The crushed stalks and the remainder of the plant have value as by-products, mainly for stock feed. The bagasse is sometimes used for fuel and for other purposes.

This bulletin describes cultural methods for the production of sorgo for sirup-making purposes as well as methods of harvesting and handling the crop.

Formaldehyde, copper carbonate, arsenics, and carbon disulphide, materials mentioned herein, are scarce in wartime. Copper carbonate is considered best for treating sorgo seed, but other metallic compounds such as Ceresan may be used.

Washington, D. C.

Issued January 1930
Slightly revised August 1942

SORGO FOR SIRUP PRODUCTION: CULTURE, HARVESTING, AND HANDLING

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INTRODUCTION

SORGO is the name now used for the varieties of sorghum that have abundant sweet juice, the name being applied to distinguish these varieties from grain-producing and other varieties. These saccharine or sweet varieties are sometimes called sweet sorghums and saccharine sorghums. The sorghum species includes kafirs, milos, and kaoliangs, cultivated for their grain; broomcorn, cultivated for the brush from which brooms are made; grasslike forms, such as Johnson grass and Sudan grass, cultivated for forage; and sorgo, cultivated both for making sirup and for forage. The grain sorghums are mainly grown in a geographical region different from that in which sorgo is grown for sirup production, this also in a large measure being true with regard to sorgo when grown for forage purposes. Climatic conditions as well as soil types are in general different in these two regions, and cultural methods and methods of handling the crop differ, because of the difference in utilization. At earlier periods the plant was given extensive investigation as a possible source of commercial sugar.[2] Some of this

[1] Acknowledgments are made to S. F. Sherwood, senior biochemist, for analyses of sorgo juices, and to the Bureau of Entomology, U. S. Department of Agriculture, for the section on insects injurious to sorgo.

[2] BOLLMAN, L. CULTIVATION OF THE SORGHUM. U. S. Dept. Agr., Commr. Agr. Rpt. 1862: 140–147. 1863.

CLOUGH, W. SORGHUM, OR NORTHERN SUGAR-CANE. U. S. Dept. Agr., Commr. Agr. Rpt. 1864: 54–87, illus. 1865.

WILEY, H. W. THE SUGAR INDUSTRY OF THE UNITED STATES. INTRODUCTION. PART I.—CANE SUGAR. PART II.—BEET SUGAR. PART III.—SORGHUM. PART IV.—MAPLE SUGAR. U. S. Dept. Agr., Chem. Div. Bul. 5, 324 p., illus. 1885.

information is applicable to present-day conditions in the growing of the crop for sirup-making purposes; but much of it is not applicable, and much of it is now out of date. This bulletin has been prepared to give recommended practices in the culture and management of the crop, including planting, cultivating, harvesting, and handling, applicable to conditions prevailing at the present time.

The production of sorgo sirup has varied considerably from year to year. According to census estimates it amounted to 16,532,000 gallons in 1909. In 1920 the production had increased to 49,505,000 gallons, according to estimates of the United States Department of Agriculture, and the average price received by producers in that year was $1.069 a gallon, making the value of the crop in that year approximately $52,922,000. This large increase in production and the price received per gallon were due partly to a scarcity of sugar following the World War. Subsequent to 1920 there was a decrease both in production and in price received by producers, 24,926,000 gallons, having an average value of 94.9 cents, being produced in 1925, according to Department of Agriculture estimates, and 26,972,000 gallons, having an average value of 91.5 cents, in 1928.

Sorgo sirup is much more commonly used in the States where it is produced than in other sections. The homemade product is often of very high quality, being light in color, mild, and of fine flavor. It is well liked as a table sirup, especially by those who are accustomed to it. Without doubt it is a wholesome food product.

PROCESS OF MANUFACTURE OF SORGO SIRUP[3]

The methods employed in the manufacture of sorgo sirup are briefly presented here in order better to show the requirements and the relation that cultural, harvesting, and handling practices bear to quality.

The making of sirup from sorgo, whether done with the usual farm equipment or in a commercial factory, consists essentially in pressing the juice from the stalks—usually by passing them through mills consisting of steel rolls; removing impurities from the juice; and concentrating the juice by evaporation. The leaves and seed heads are usually removed from the stalks before the milling process takes place; when the crop is made up with the usual farm outfit they are generally removed before the stalks are hauled from the field, but in commercial factories the leaves and sometimes the heads are not removed until the stalks have reached the factory. Impurities in the juice are largely eliminated either just previous to or during the process of boiling it down. Heating causes some of the albuminous substances contained to coagulate and rise to the surface, carrying with them other particles of solid matter present, including particles of the leaf sheaths and stalks. Where sirup is made on a small scale, these are removed by skimming, but in commercial factories pressure filters are often used. Filtration may be assisted and jellying of the sirup avoided by treating the juice with extract of malt. Water is sometimes applied during the milling process in the factories to help remove sugar-bearing juice; lime is sometimes

[3] The making or sorgo sirup is treated more fully in the following publication: U. S. Dept. Agr. Farmers' Bul. 1791, Farm Production of Sorgo Sirup.

introduced to counteract some of the acidity and to assist clarification; and either from the start or only during the final concentrating or finishing process the juice is sometimes boiled under a partial vacuum at a comparatively low temperature in order to hasten evaporation and to avoid scorching the sirup.

EXTENT OF CULTIVATION OF SORGO FOR SIRUP MAKING

The adaptability of the sorgo crop to many soils and climatic conditions is noteworthy. It is cultivated over a wide area, being now grown to some extent for sirup making in 35 or 40 States, including States with as diverse climatic conditions as Minnesota, Alabama, Indiana, and New Mexico. Commercial sorgo-sirup fac-

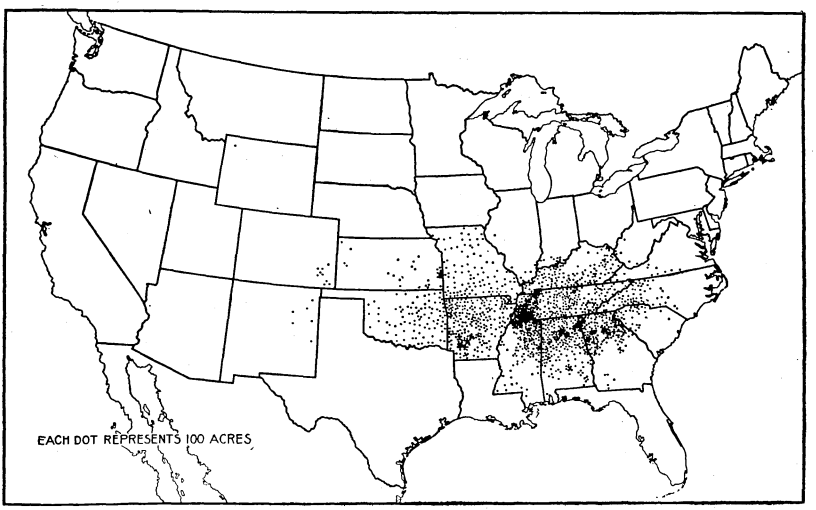

FIGURE 1.—Outline map showing the distribution of the cultivation of sorgo for sirup-making purposes in the chief sirup-making States in 1924, taken from the United States Census of Agriculture of 1925. The largest acreage was in Tennessee, 27,802 acres, followed by that of Arkansas, 26,218 acres. Acreages not shown on the map include those of Texas, 7,610 acres; Iowa, 1,288; Colorado, 1,084; Florida, 723; and Minnesota, 681

tories are operated in States with as diverse climatic conditions as Minnesota and Arkansas. The crop is grown most extensively as a source of sirup in the Southern States. A so-called sorgo belt extends from Virginia, West Virginia, North Carolina, South Carolina, and northern Georgia through Kentucky, Tennessee, Missouri, Arkansas, and Oklahoma, including also the northern parts of Alabama, Mississippi, and Louisiana. (Fig. 1.) For the most part, the production of sirup is on a small scale. The average area grown for sirup-making purposes on individual farms is somewhat less than an acre. It is therefore a secondary crop on most farms, the sirup being made in the neighborhood for home use, or with a small surplus for sale. When sorgo is grown for the use of commercial factories the growers generally produce the crop on contract. The product of the factories is sold through the usual trade channels.

DESCRIPTION OF THE SORGO PLANT

Sorgo is a member of the grass family. It is less closely related to sugarcane than it is to kafir, milo, feterita, broomcorn, Johnson grass, and Sudan grass.[4] These latter belong to the same species of plants as sorgo. Sorgo is perennial in the Tropics but winterkills in regions where frosts are severe.

Young sorgo plants are delicate, and growth is slow. In germinating, the radicle (the first root) bursts through the seed coat only slightly before the plumule, which later develops into the sprout that grows upward. In its upward growth the plumule forms the first node or joint always just beneath the soil surface, where it puts forth permanent roots. When the seed is planted deep the plumule may grow 2 inches or more in length before forming a node. At this point the growth of the permanent plant commences, the seedling portion withering and dying after a number of nodes together with their permanent roots have developed. The temporary development of the plant is sometimes thought to be a taproot, but this is a mistake, as the sorgo plant has no taproot.

After the seedling stage, the early growth above the surface appears to consist mainly of leaves. The stalk, however, is developing during this period—at first mainly by the formation of nodes very close together. These increase in size successively, and very soon there is some development of stalk between the early formed nodes. The internodes are very short at first, but they increase successively in girth and to some extent in length, thus forming a somewhat cone-shaped base for the stalk. A leaf is produced at each node, the bases or sheaths of the leaves closely surrounding the stalk. The internodes from this time grow more rapidly and become much longer. The number varies both with the variety and with individual stalks, but in most cases the average number above the surface of the soil is from about 8 to 12. The stalk tapers from the base toward the summit, but the last internode, or the peduncle of the head, is about uniform in thickness. The exterior of the internodes is hard and tough, being composed to a large extent of fibrous material called fibrovascular bundles. Over the surface there is a thin film of waxy bloom which is white in early stages, but becomes dark in maturing. The interior of the stalk is mainly composed of soft pith which contains sweet juice. The peduncle, however, is somewhat more fibrous than the other internodes.

Permanent feeding roots for the most part originate from the lower nodes or joints of the stalk that are beneath or slightly above the surface of the soil. They are always most abundant in the surface soil and radiate in all directions. The plant obtains its mineral nutrients largely from the upper foot of soil, although some of the

[4] Sorgo is most easily distinguished from sugarcane by the fact that it always produces a small or medium-sized seed head at the summit of the stalk, the seed produced in this head being about one-eighth inch long. Sugarcane, on the other hand, does not produce seed in the United States, except in southern Florida, and the inflorescence which bears the seed is several times as large as the inflorescence (head) of sorgo, while the seed is much smaller than the sorgo seed. The stalk of sugarcane has a harder rind, and the plant usually tillers more abundantly than sorgo. Many varieties of sugarcane shed their leaves as the plants approach maturity, which is not the case with sorgo. The term cane should not be used when sorgo is referred to, and the terms Ribbon cane, Japanese Ribbon, and Texas Seeded Ribbon are also objectionable when used in reference to varieties of sorgo, as Ribbon and Japanese are names applied to varieties of sugarcane.

roots often extend as much as 3 or 4 feet downward. When the soil is moist, roots may be put forth also from nodes that are considerably above the surface, as well as from nodes still farther upward on stalks that have lodged. These are strong and tough, and those from the lower nodes help to anchor the plant to the soil.

When the plants have attained a height of 3 to 6 inches some of the buds at lower nodes develop into shoots which later become secondary stalks or tillers. In early stages these tillers can be distinguished from initial stalks, as they grow out obliquely. Later their direction of growth becomes upright and they develop independent root systems, and it is difficult to distinguish them from the initial stalks. They are equal to initial stalks for sirup making, except that they mature later. The lack of uniformity in the maturity of the stalks and tillers may sometimes affect the quality of the sirup.

Both initial stalks and tillers put out short branches from their upper nodes, branches being most abundantly produced when the plants are approaching maturity and when rains occur after a period of dry weather. Under normal conditions each branch is terminated by a head. When stalks become lodged after reaching maturity, branches growing from them sometimes become rooted to the soil and have an independent growth, but this can occur only when the variety reaches maturity sometime before killing frosts. The branches, as well as tillers, are frequently called "suckers"; but this term is a misnomer and does not distinguish between them. Branches are of no value for sirup making. Juice expressed from them contains more impurities than the juice from the stalks and is often dark in color; no doubt this is due to the fact that a large part of the branch is the peduncle of the head which surmounts the branch.

CULTURE

The primary purpose in producing the crop is to obtain the largest possible yield of sirup of good quality, rather than a large tonnage of stalks or a high yield of grain, as in the case of sorghums grown for forage and grain, and the method of culture is therefore somewhat different. The requirements in general are more exacting, and methods of handling are more expensive than when sorgo is utilized for forage. The yield of sirup depends primarily on the tonnage of stalks, the amount of expressible juice, and the proportion of sugar in the juice. There are also secondary factors which affect the yield, the economy of handling the crop, and the quality of the product. These include uniformity in the growth of the stalks and uniformity in reaching maturity, the erectness and size of the stalks, the ability to withstand deterioration after reaching approximate maturity, and the relative freedom from undesirable substances that would enter the juice and as impurities to a greater or lesser extent lower the quality of the sirup.

The yield is more under the control of the grower than are the other factors, because by a wise choice of varieties, efficient cultural practices, and the use of fertilizers he can often obtain increased tonnage of stalks. In general, the largest yields are obtained from varieties that require the longest periods for their development, and

maximum weight of the stalks occurs when the growth of the plants has attained its maximum and the cells of the pith contain the largest proportion of sugars.

SELECTION OF THE FIELD

Sorgo can be grown on many kinds of soil, being much less exacting in this respect than many other crops; but in order to obtain the best yields a soil of good physical character and high fertility should be chosen. On the poorer soils it is more difficult to get a satisfactory stand; growth is slower, and the stalks do not reach as large size. The field should have good natural drainage, especially in localities where there are liable to be periods of excessive rainfall; and if the planting is to be done early in the season, a soil that becomes warm early should be selected. A loam or a sandy loam is better than a clay or a silt soil, the former being warmer, better drained, usually more fertile, and having less tendency to form crusts through which the sorgo seedlings are unable to push to the surface.

A belief prevails in some localities that certain kinds of soil have a pronounced effect upon sirup quality. Crops grown on light-colored sandy soils, as well as on light-colored upland soils of a heavier texture, are thought by many to give sirups of finer flavor and better color than those on heavy, dark soils. It is probably true that in general it is more difficult to obtain sirup of high quality from crops produced on soil rich in organic matter, because the leaf sheaths around stalks grown under such conditions contain more green chlorophyll, and the tissues are softer, with the result that more undesirable matter is crushed out. Sirup of good quality, however, is frequently made from crops grown on soils especially rich in organic matter; and the effect of the soil on quality is apparently much overestimated. Since practically all cultivated soil contains organic matter, it is difficult to say when the quantity is excessive.

PLACE OF SORGO IN ROTATION WITH OTHER CROPS

Consideration should be given to the crop that was grown on the land in the preceding year and to what crop will follow sorgo. Cropping systems in which sorgo is grown are varied. This is due largely to the fact that sorgo is cultivated over a wide area. In much of the southeastern division of States, where sorgo is most extensively grown for sirup making, as well as in Arkansas and parts of Louisiana, Oklahoma, and Texas, cotton is the chief crop. When sorgo is grown in these sections it is generally made to fit into any system of cropping followed in the production of cotton. Some such system as the following is often practiced: (1) Cotton the first year; (2) sorgo the year following the cotton crop, with or without cowpeas between the rows planted at the last cultivation; and (3) winter wheat or oats in the third year, followed by cowpeas as a catch crop. Cotton is generally given clean cultivation. It is for this reason a good crop to precede sorgo, there being fewer weed seeds in the soil to grow and interfere with the development of the sorgo seedlings; and even on upland soils that are not best suited to growing corn, sorgo may usually be successfully grown following cotton.

In the Northern States sorgo may be substituted for corn in the system of cropping followed.

The cultivation of sorgo is similar to that of corn. Because the more leafy growth of sorgo causes more shade, and because of the difficulty of harvesting the sorgo without to some extent injuring the catch crop, it is less suitable as a crop to be followed by such leguminous crops as cowpeas and soybeans between the rows.

In many cases it is feasible in the Southern States to grow a winter cover crop on the land following sorgo. Such crops tend to prevent the leaching out of soil nutrients and add humus and nitrogen to the soil when they are turned under. When such a crop can be grown and the land subsequently gotten ready early enough for the succeeding crop, it is often a good practice. Bur clover, crimson clover, hairy vetch, rye, and barley are some of the crops that have been recommended for this purpose.

Sorgo is generally considered somewhat hard on the soil, the opinion being common that sorgo, as well as grain sorghums, leave the soil in poor physical condition and that the yield of the crop following sorgo or other sorghums may be somewhat reduced. The effect is not permanent. It is advisable to keep in mind this more or less injurious effect when selecting a field, even though the effect is temporary. The crop that follows should not be one that is easily affected by adverse conditions. Among crops that have been successfully grown are the following: Oats, planted in March or April following sorgo harvested as late as October or November; cowpeas following oats planted as above, or planted in May on land that was in sorgo the previous year; velvetbeans and soybeans planted in May or June on land that was in sorgo the previous year.

CLEARING AND PREPARING THE LAND

Thorough preparation of the soil is always advisable. The field should first be cleared of all growth of a character that will not quickly decay when plowed under. It should then be broken with the plow as deeply as possible without turning up considerable quantities of subsoil and worked down into a good seed bed. Precautions should be taken to have the seed bed free from weeds, as free as possible from weed seed, and firm enough to promote capillary movement of moisture. The above ends are facilitated by the use of the harrow, and the disk harrow is especially recommended, because it is very effective in destroying young weeds and packs the soil beneath the surface. Considered only from the viewpoint of maximum growth, the land should be plowed in the fall or winter, or early in the spring, in order to allow the remains of a preceding crop or other growth to become at least partly decayed before planting time and to facilitate the acquisition of moisture for the crop, but when man and team labor are abundant it may be better to plow, harrow, and plant at the proper time for planting, as it is often possible in this way to prepare the land when conditions are most favorable and to utilize the moisture present in the soil for the germination of the seed. There is then also not as great a loss of soil nutrients by erosion.

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Provision should be made for carrying off excess surface water from the field, especially when natural drainage is poor and where spring rainfall is normally heavy. Standing water is often injurious. It may cause the soil to crust or bake, in this way preventing young shoots from reaching the surface, and it sometimes kills or weakens the plants after they are up, especially in early spring when the soil is not thoroughly warm and when night temperatures are low. After the plants are thoroughly established in the soil, little injury results from standing water. Ditches may be provided through or around the fields. They should be made in such a manner that excess rainfall will be carried off with the least washing or eroding. It is the usual practice in some localities to ridge or bed the field, either with a lister or by turning two furrow slices together with a single moldboard plow. The planting is then on the ridge. (See fig. 10, p. 31.) If properly done a firmer seed bed is thus obtained, and trash, clods, and often much weed seed are thrown out of the rows into the furrows. It is generally not necessary or advisable to make the ridges high, and it is good practice partly to level them down by dragging off the tops with a plank drag. In some cases growers open a shallow water furrow on top of the ridge for the planting. The soil remains moist for a longer time in these water furrows, as water from light rains collects in them. The deeper furrows on each side of the ridge carry off the excess water.

In localities where rainfall in the spring is often excessive, planting on ridges tends to a more uniform stand, and growth is enhanced at a time when the plants are passing through their most delicate period, the soil in the ridges being drier, warmer, and in better physical condition.

Ridging as usually done has some disadvantages: (1) The expense is greater for both preparation and cultivation, and (2) the rows have a greater tendency to dry out in dry weather. By making the lister furrows shallow and the water furrows somewhat deeper than is customary, the first disadvantage is largely overcome, as the cultivation then becomes level or nearly level after the first or second time over the field, and the cost of cultivation is then about the same as when the planting is on the level field. The method is not as suitable for the drier sections, or for semihumid sections where the planting is done after the soil has become thoroughly warm. Evaporation is then generally sufficient to take care of the excess moisture.

USE OF FERTILIZERS

Whether the use of fertilizer is advisable depends primarily on the fertility of the field. Sorgo responds well to applications of either barnyard manure or commercial fertilizer. Fertilizer helps to get a stand and to get the plants through the first two or three weeks of growth, beneficial results often being noticeable soon after the seedlings emerge through the soil. Later growth is also often more vigorous on naturally fertile soil or soil that has been treated with a fertilizer. (Fig. 2.) The use of fertilizer sometimes makes a difference of 10 days or 2 weeks in the maturity of the plants, the yield of sirup being considerably increased and the mature stalks being larger.

The formula that should be used will depend much upon local conditions. The experience of the grower or his neighbors with fertilizers for grain sorghum or for other crops may be used as a partial guide until fertilizer tests have been made. In experiments [5] with fertilizer for sorgo on clay, clay loam, and silt soils, 300 pounds per acre of a mixture containing 6.18 per cent nitrogen (equivalent to 7.5 per cent ammonia) and 7.5 per cent phosphoric acid was an economical application. No benefit followed from the use of potash in these experiments.

Much of the needed nitrogen may be supplied by growing leguminous crops, either as catch crops or in rotation with the sorgo crop. When this is done, unless fertilizer tests indicate that potash is needed, purchased fertilizer should contain a relatively large proportion of phosphoric acid. This may be supplied either in the form of acid phosphate or as bone meal. The additional nitrogen needed may be supplied in the form of cottonseed meal, sulphate of ammonia, or nitrate of soda, or all three may be used.

FIGURE 2.—Beneficial effect of an application of fertilizer on the growth of sorgo. The rows on the left (A) received no fertilizer; those on the right (B) received an application of fertilizer containing 6.8 per cent of nitrogen, equivalent to 7.5 per cent of ammonia, and 7.5 per cent of phosphoric acid, applied at the rate of 500 pounds per acre

Commercial fertilizers and cottonseed meal should be applied in the row either a short time before or at the time of planting. Sometimes only a part is applied at that time, the remainder being used as a side dressing at one of the cultivations. In many sections a part or all of the summer season is often droughty, so that there is not moisture enough in the soil to make available such fertilizer as is applied late in the season. The probability of beneficial results is therefore not as great from fertilizer applied as a side dressing as from that applied in the row before or at the time of planting. It is advisable to apply the fertilizer when the soil is somewhat moist. The seed should never be allowed to come in direct contact with it,

[5] Fertilizer experiments conducted cooperatively by the Office of Soil Fertility, Bureau of Chemistry and Soils, the Office of Sugar Plants, Bureau of Plant Industry, and the Best-Clymer Manufacturing Co., in the vicinity of Fort Smith, Ark., 1919 to 1921.

especially if it is composed of chemical ingredients. This may cause the seedlings to "burn." On this account, as well as to reduce to a minimum losses from leaching, the fertilizer should be covered or incorporated with the soil. Sometimes it is applied in rows on the surface and two furrow slices are turned together over it, the seed being planted on the ridges. In other cases the fertilizer is applied in shallow furrows and covered or incorporated. There are several types of planter having fertilizer attachments that successfully deposit fertilizer and cover it either before or after dropping the seed. (Fig. 3.) In the latter case the seed is covered with a thin layer of soil before the fertilizer is deposited.

CHOICE OF SEED FOR PLANTING

When obtaining seed both the variety and the quality should be given consideration, because the large numbers of varieties now

FIGURE 3.—Two 2-row planters with fertilizer attachments suitable for planting sorgo

grown vary greatly with regard to the length of their growing period and their sugar content at time of harvest, as well as with regard to other characteristics that may affect the quantity and the quality of the sirup produced. The normal growing period for different varieties varies from 75 to 150 days. Although all of these may be grown in the Gulf States and many of them in the Central States, the limiting factors of late spring frosts, necessitating late planting, and early killing frosts in the fall result in only a limited number of early-maturing varieties being suitable for culture in the Northern States.

There is at present much confusion in regard to the varietal names, and until standard varieties are better recognized it may be difficult to obtain seed of superior varieties. It is a better practice to plant a variety that is known to have given good results in the community than to obtain seed from outside sources. When it is necessary to obtain a new variety, field tests and analyses made by

the United States Department of Agriculture, State experiment stations, and others should be consulted.[6]

Although varying climatic conditions from year to year affect the length of the growing period to a considerable extent, the early varieties under normal conditions reach the hard-dough stage—which is the most suitable state of maturity for harvesting for sirup production for a large number of the varieties—in 75 to 100 days from date of planting. Early-maturing kinds called Amber varieties are the most suitable for the more northerly States, where the growing season is shortest. There are a number of these, and they vary considerably in sugar content, yield of stalks per acre, and other characteristics. Minnesota Amber, which normally requires 85 to 95 days to reach the proper stage of development for sirup making, is one of the best of this group, although Indiana Amber, which develops in about the same length of time, is favored in some localities.

A number of medium-late varieties maturing in 100 to 125 days are grown in certain districts. Among them the following are recommended for sirup making: Folger, Red X, McLean, Sapling, Sugar Drip, White African, and Sumac. Folger is the earliest of this group, normally reaching the hard-dough stage in 100 to 110 days. It has a high sugar content and is considered by many growers a superior sirup variety. The other varieties just named normally require 110 to 125 days, the last three usually needing a somewhat longer time than the first three. Red X has proved to be one of the best of all varieties now being cultivated with regard to sugar content. The varieties in this group are suitable for localities in the Central States where the season is intermediate in length.

Honey and Gooseneck are two late-maturing varieties that are recommended. There are a number of strains of the Honey variety that differ with regard to the number of days required to mature, the most commonly grown strain requiring normally about 125 to 135 days. This variety is commonly cultivated in the southern part of the sorgo-sirup belt. Though its sugar content is not as high as that of some others, in general this is more than compensated for by a higher yield of stalks per acre. The sirup obtained is also considered by many to be of superior quality.

Gooseneck usually affords a heavy yield of stalks per acre and a juice high in sugar content. It requires 125 to 150 days to reach the proper stage for harvesting, depending on climatic conditions. In general it is somewhat less popular with growers than Honey, probably due largely to the fact that the gooseneck type of heads interfere more or less with the handling of the crop after it is cut.

The quality of the seed is second in importance only to the variety chosen. Pure, well-cleaned, plump, well-developed seed, which has shown a high germination percentage by test, should be used. Seed produced in the year preceding is more certain of giving satisfactory results than older seed, although seed 3 or more years old will sometimes germinate and produce a good crop. Frequently commercial seed is impure. This condition materially lowers its value. When

[6] Provisional descriptions of 16 varieties of sorgo are given in the following publication: COWGILL, H. B. VARIETAL STANDARDIZATION OF SORGO AND THE SELECTION OF SEED. U. S. Dept. Agr. Circ. 52, 23 p., illus. 1929. Out of print, but may be consulted in libraries.

the seed contains a large proportion of chaff the resulting stand is liable to be more or less uneven, due to irregular distribution by the planter.

It is advisable to test the seed for germination, especially if it is not bright or shows any other signs of being of low vitality. The tests may be made by placing counted samples at regular intervals between sheets of blotting paper in shallow pans, keeping the blotting paper moist until the seed has sprouted, or patent germinators may be used. After sufficient time has elapsed for germination—say six to eight days—a count should be made of the number of seeds that have germinated and the percentage of germination thus determined. If the seed has been kept in the head until just previous to planting, the viability of individual heads may be determined by taking samples at random from each head and testing them in the above manner. The best heads only should be retained for planting. If it is not possible to obtain seed showing good germination, a relatively larger quantity per acre should be planted.

In some cases it may be advisable to treat the seed for the prevention of smut. (See pp. 36 and 37.) This would be especially desirable if the grower expected to sell pure, high-grade seed to the trade.

TIME OF PLANTING

It is advisable to time the planting so that the crop will reach the proper stage for harvesting when other farm work will not interfere. In the cotton-growing States it is desirable to have cotton picking completed before it becomes necessary to harvest the sorgo. The most suitable time will vary in different localities, different fields, and different years. In the Northern States it is advisable to plant as early as possible so that the crop may mature before killing frosts. This is also true in the Central States with regard to varieties that require a long growing season.

From the viewpoint of soil temperature it is desirable to delay the planting until the soil is thoroughly warm. This results in better germination and early growth and insures a more uniform stand. A vigorous early growth necessitates less cultivation and hoeing, and the crop may be laid by at an earlier date. However, an adequate supply of moisture is essential for satisfactory germination and early growth. For this reason it is not advisable to delay planting until rainfall is scant and the warming of the soil has resulted in an excessive loss of moisture. The soil may be so dry as to make it necessary to wait for rain or to replant the field later in the season. In either case the planting may be so late that the crop will not have time to mature properly.

When a comparatively large acreage is grown it may be well to make an initial planting as early as possible, following this by one or more later plantings, the purpose being to avoid having the entire crop reach maturity at one time. Harvesting and sirup making may thus extend throughout a longer period. This, however, often can best be accomplished by growing a number of varieties requiring different periods for maturing.

The planting period ordinarily extends from about May 10 to 31 in the Northern States, from April 20 to June 15 in the Central States, and from April 1 to June 15 in the Southern States.

METHOD OF PLANTING

The planting may be on the level field, on ridges or beds previously prepared, or in furrows. Planting in furrows is suitable for localities where spring rainfall is frequently deficient, or at least not excessive. More moisture is available for germination and early growth. Cultivation is also facilitated as it is easier to cover weeds and there is little danger of injuring the young plants. But in localities where heavy rains frequently occur, especially if the soil is heavy, it is better to plant either on the level field or on prepared ridges or beds. If planted in furrows, the seed or seedlings may be covered so deeply by the washing of soil upon them that sprouts and new leaves can not push through to the surface.

In selecting a planter the grower should see that provision is made so that the right number of seeds may be dropped at a place. In case the number of seeds dropped is regulated by the size of holes in the planter plate, it is sometimes necessary to obtain blank plates and have these bored with holes of the proper size and at the proper distance apart. Some manufacturers supply plates properly bored for sorgo. It is important also to see that provision is made for firmly pressing the soil in the row after the seed has been deposited, so that capillary movement of moisture from below may be facilitated. This is often done by means of concave wheels, or double wheels, which pass over the rows immediately after the seeds have been dropped. In general the 2-row type of planter is better adapted for depositing the seed at a uniform depth and for pressing the soil over the row, and better germination appears to result when this type is used. (Fig. 3.)

DEPTH OF PLANTING

The proper depth for planting depends upon the kind of soil and the amount of soil moisture. If possible the seed should always be planted in moist soil, but it should never be covered more than an inch deep, a half inch being sufficient if the soil is quite moist. Shallow planting is preferable on heavy soils which retain moisture, but deeper planting is necessary on light soils which have a tendency to dry out rapidly.

DISTANCE OF PLANTING

Rows should be spaced at a suitable distance to permit easy cultivation and harvesting, a space of 3½ feet being satisfactory unless intercropping with such crops as cowpeas and soybeans is practiced. In the latter case the rows should be at least 5 feet apart. The planting may either be in continuous drills, with the expectation of thinning to the desired stand, or the seed may be dropped in hills or at regular intervals in the row at the rate of three to eight seeds to the hill. The continuous drill method usually insures a more perfect stand, but the greater quantity of seed required and the necessity for thinning renders it more expensive. Moreover, unsuitable weather sometimes renders it impossible to thin at the proper time, and this results in the growth being retarded and the yield of stalks reduced on account of the stand being too thick. If the soil is moist

and in good condition and the seed of high vitality, to drop a number of seeds at regular distances in the row is preferable.

The proper distribution of the seed depends upon the available fertility of the soil, the variety, and the method of planting. More seeds may be planted where plant food and moisture are abundant. On the average, a satisfactory stand may be obtained if three or four seeds germinate in each hill and the hills stand 10 to 14 inches apart in the row, but on poorer soils the hills should stand somewhat farther apart, and on the other hand if the seed is planted in check-rows a correspondingly larger number of seeds should be dropped in each hill.

The results of an experiment relative to the effect of spacing upon the number of tillers produced by sorgo plants are given in Table 1. Five varieties were used, and the plants were thinned to distances in the rows indicated in the table. The distance between rows was 40 inches. The count of the number of tillers was made at 51 to 55 days after planting. The results indicate that fewer tillers are produced when the plants are close in the row than when they are farther apart. It is also indicated that there is a tendency toward greater uniformity in the stand when the seeds are planted in hills than when planted at approximately equal distances in the row, because in case of uneven germination the stand tends to become uniform through the production of tillers.

It will be noted that with three varieties one row each was not thinned. In these rows the plants stood an inch apart, or less, in the row. None of the plants in these rows produced more than 2 tillers, whereas the average number was one-fifth tiller per plant, or an average of 1 tiller to each 5 plants. On the other hand, rows spaced to a single plant every 2, 3, 6, 9, and 12 inches produced tillers in larger numbers, the 12-inch spacing resulting in an average of approximately 3¼ tillers per plant, 1 plant producing 12 tillers, 3 producing 9 each, and 4 producing 8 each. In rows spaced so that three plants were left together at distances of 3, 6, 9, and 12 inches in the row, tillers were produced less abundantly than where single plants were spaced at these distances.

A preliminary count was made at 37 to 41 days after the planting. The number of tillers where the spacing was wide was in general greater at the time of the count recorded in Table 1 than at the time of the preliminary count.

TABLE 1.—*Effect of spacing sorgo plants in the row on the production of tillers*

Distance between plants in the row	Number of plants counted	Number of varieties included	Tillers per plant		Distance between plants in the row	Number of plants counted	Number of varieties included	Tillers per plant	
			Average number	Largest number				Average number	Largest number
Row not thinned	630	3	0.20	2	1 every 6 inches	534	5	2.68	8
1 every 2 inches	962	5	1.15	7	3 every 9 inches	1,032	5	1.14	6
3 every 3 inches	1,050	5	.68	5	1 every 9 inches	402	5	2.88	7
1 every 3 inches	788	5	1.55	8	3 every 12 inches	777	5	1.32	7
3 every 6 inches	969	5	.78	7	1 every 12 inches	326	5	3.27	12

It is often evident from observation that close planting reduces the average number of tillers per plant, and the results of this experiment are confirmatory of these observations.

QUANTITY OF SEED PER ACRE

When the planting is in continuous drills, 4 to 10 pounds of seed per acre are needed. Differences in quantity are due to differences in planters, in the size of the seed, in its viability, in the proportion of chaff on or intermixed with it, and in the moisture content and character of the soil at different periods. When the planting is at intervals in the row, the planter being regulated to drop approximately only enough seed to make the desired stand, no thinning being contemplated, 2½ to 5 pounds are needed. The average number of seeds per pound is about 25,000 or 30,000, varying with the variety, and there are between 25,000 and 50,000 plants per acre when the stand is complete. Two and one-half pounds therefore would be more than sufficient if every seed germinated and developed into a plant.

IMPORTANCE OF A UNIFORM STAND

Precautions should be taken as far as possible to have the stand complete and uniform throughout the field. When sorgo is cultivated for sirup the stand is of great importance, a poor stand resulting in decreased yields and more or less increase in the expense of growing, harvesting, and handling; whereas, when the stand is too thick the stalks do not develop to their full size, some of them often remaining grasslike. The quality of the sirup is also often lowered, because the stalks reach maturity unevenly. Further, the percentage of leaves is usually greater on small stalks and the expense of stripping, cutting, and handling is greater, especially when these operations are done by hand. Operators of small mills prefer stalks that are not too large in girth, because they are easily milled; but this is not the case when the crop is made up in a commercial factory, and large stalks are desired because they are more economical to handle.

Uniformity of maturity is of importance on account of the effect of an uneven development on the quality of the sirup. When the plants stand close there is always competition between them for plant food in the soil, and plants that begin growth first usually outgrow those germinating later. On this account such plants reach maturity and pass through their period of decadence somewhat earlier than the others. For this reason it is impossible to harvest the field at the most favorable time for all the stalks, and as a result the quality of the sirup may be lowered.

Poor stands result from inferior seed, from the soil being too cool for the best germination, from lack of soil moisture, from insufficient drainage, or from neglect of the crop. Although the plants tiller more abundantly and both the stalks and the tillers have a tendency to grow larger where the stand is scant (which partly compensates for the lack of plants in the row), frequently the stand is so poor that wide gaps occur. Sometimes, the gaps are replanted by hand at the time of the first cultivation of the field. This usually results

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in the crop's reaching maturity more or less unevenly; and it is usually a better practice, if the season is not too far advanced, to disk or replow and replant the entire field. In some cases it is practicable to fill in the gaps by transplanting young sorgo plants when thinning out the rows. If the plants are still small at the time of thinning and the soil is moist, transplanting can easily be done, and the stand can be made perfect. Care always should be taken when transplanting to raise a ball of earth about the roots of the young plant; and after it has been set all leaves except those of the greener inner whorl which have not yet reached complete development should be pinched off to about half or one-third their original length.

GROWTH AND DEVELOPMENT OF THE CROP

A steady uniform growth should be maintained in sorgo grown for the making of sirup. The sorghums, including both sorgo and the grain-producing varieties, without doubt withstand drought better than many species of plants. Nevertheless, when rainfall is deficient growth is usually checked, and though it may be resumed if rains occur later in the season, the tonnage of stalks is reduced in seasons in which the rainfall is either deficient or is poorly distributed throughout the growing period. If the dry period comes when the stalks are partly developed, the checking and the subsequent resumption of growth apparently has the effect of lowering the quality of sirup made.

Lack of moisture can be withstood much better at certain stages in the development than at others. Moisture is of course requisite for germination. If there is a deficiency, germination is almost certain to be poor, and the resulting stand scanty. Though seed may lie in the soil two weeks or more and then germinate if an abundant rain occurs, usually many of the seed lose their vitality if there is not enough moisture for germination within a short time after they are put into the ground. This is especially the case if the soil is slightly moist at planting time. This usually causes some of the seed to start to germinate and then die. Seedlings require less moisture than older plants, but they are not able to withstand prolonged dry periods, because their root development is scant. They sometimes suffer severely during dry periods and many die, this being most liable to happen if the stand has not been thinned and if early cultivation had not been given. During the time that the crowns of the plants are being formed and permanent roots are being put forth abundant moisture is requisite for maximum development. Observations covering a number of years indicate that a deficiency of moisture tends to result in stalks of small girth and a reduced tonnage. During the period that immediately follows the development of a permanent root system a deficiency of moisture can be withstood much better. The permanent roots absorb moisture from wider areas and somewhat lower levels than the temporary roots of the seedlings. This is especially true with late-maturing varieties, which in general grow more slowly, forming larger crowns and more extensive root systems than early-maturing varieties. Dry weather that comes when the plants are getting ready to put forth seed heads or slightly before has a tendency to delay development; but if the dry period comes just as the heads are about to emerge, it often causes prema-

ture development. The heads sometimes do not get out of the sheaths and do not produce seed. In other cases, they get partly out and a small quantity of seed is produced. As the head terminates the elongation of the stalk, subsequent growth is by the production of branches, which are of no value for sirup making.

Internodes formed when growth is retarded are somewhat shorter than those formed when conditions are normal. The proportion of nodes to internodes is therefore greater, and this is evidently one reason why stalks that develop slowly or intermittently yield sirup inferior in quality. Tests that have been made have indicated that juice from the nodes is darker and contains less sugar and more impurities than juice from the internodes. This is shown in Table 2, giving the results of separate analyses of the nodes and the internodes of three varieties, and it will be noted that in the case of each variety the percentage of sucrose and the percentage of total sugars was greater in the internodes than in the nodes. The columns headed "Total sugars ÷ Brix" indicate the relative purity of the juices in regard to sugars contained, the average for the juices from the nodes being 77.7 per cent and that for the juices from the internodes 81.8 per cent. Juices from the nodes were a dark greenish color, whereas those from the internodes were a light greenish yellow, and the latter were clearer than the former.

TABLE 2.—*Chemical analyses of the juices from the nodes and the internodes of three varieties of sorgo*

Variety	Analyses of the juice of the nodes					Analyses of the juice of the internodes				
	Density [1]	Sucrose [1]	Reducing sugars [1]	Total sugars	Total sugars ÷ Brix [1]	Density [1]	Sucrose [1]	Reducing sugars [1]	Total sugars	Total sugars ÷ Brix [1]
	° Brix	*Per cent*	*Per cent*	*Per cent*		*° Brix*	*Per cent*	*Per cent*	*Per cent*	
Red X	21.80	13.52	2.80	16.32	74.9	22.40	16.17	1.51	17.68	78.9
Sugar Drip	20.90	12.71	4.35	17.06	81.6	20.80	14.38	3.32	17.70	85.1
White African	21.30	13.02	3.32	16.34	76.7	21.40	15.54	1.85	17.39	81.3
Average	21.33	13.08	3.49	16.57	77.7	21.53	15.36	2.23	17.59	81.8

[1] "° Brix" indicates the density of the juice as determined by the Brix hydrometer, or the percentage of total solids in solution. "Sucrose, per cent" indicates the percentage in the juice of the easily crystallizable sugar, sucrose, frequently called cane sugar. "Reducing sugars, per cent" indicates the combined percentages of the two sugars, dextrose and levulose, both of which, in addition to sucrose, usually occur in sorgo juice. "Total sugars ÷ Brix" indicates the relative purity of the juice with regard to the sugar contained.

Regarding other climatic factors, for optimum growth sorgo needs rather high temperatures, together with abundant sunshine, from the time of planting until about the time of heading. After that stage moderately cool temperatures are desirable. Very hot periods coming in the latter part of the growing season, especially if accompanied by a deficiency of rainfall, often have a pronounced deleterious effect. The stalks lodge and deteriorate rapidly thereafter. Chemical tests indicate that such stalks are prematurely ripe, their composition resembling that of stalks that have ripened normally. It is then advisable to commence making up the crop immediately, since many of the stalks are liable to decay and a part of the crop may be lost. This does not apply, however, to certain varieties that always have a tendency to lodge before becoming completely mature.

A single light frost usually results in no serious injury to the growing crop. The extent of the injury may be only that the extremities of the leaves are withered, or these may subsequently dry up. But if a heavy frost occurs when the plants are immature, or if even light frosts occur repeatedly at short intervals, the plants will be injured and their vitality will generally be so lowered that deterioration will follow, this commonly being accompanied by an inversion of some of the sucrose—in other words, the changing of the sucrose into dextrose and levulose—and in some cases by a lowering of the specific gravity of the juice.

Degeneration due to frosts is always evident to the sirup maker, as the juice gives off a putrid odor when heated. The relative degree of injury sustained by stalks in varying stages of development will be evident to anyone who examines a field after a few days of warm weather have elapsed following a severe frost. The more immature stalks fall over. The effect on composition will be noted by comparing the figures in the columns of Table 3 showing the percentages of sucrose and of reducing sugars and the specific gravity of the juice of 26 varieties, both before and after October 6 and 11, at which dates frosts occurred. Cases in which the effects were not marked, as shown by the analyses, can be attributed to the fact that the stalks had gotten well along toward maturity before frosts occurred.

TABLE 3.—*Effect of frost on sorgo juices* [1]

[Heavy frosts occurred on October 6 and 11]

Variety	Just before Oct. 6 and 11						Just after Oct. 6 and 11					
	Juice extracted and sugars and solids not sugar in the juice				Specific gravity of juice	Equivalent readings	Juice extracted and sugars and solids not sugar in the juice				Specific gravity of juice	Equivalent readings
	Juice extracted	Sucrose [2]	Reducing sugars [2]	Solids (not sugar)			Juice extracted	Sucrose [2]	Reducing sugars [2]	Solids (not sugar)		
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*		*° Brix* [2]	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*		*° Brix* [2]
1	54.28	15.24	0.87	2.76	1.078	18.80	57.90	14.32	1.16	4.60	1.078	18.80
2	51.18	13.56	1.39	2.15	1.073	17.70	57.93	14.12	1.18	4.14	1.075	18.15
3	44.54	16.32	1.08	2.74	1.087	20.80	55.81	16.59	1.09	5.11	1.088	21.05
4	55.10	11.85	1.11	3.05	1.068	16.55	55.80	16.24	1.27	4.20	1.082	19.70
5	51.31	12.58	.70	2.40	1.068	16.55	57.44	14.65	.40	5.03	1.078	18.80
6	58.06	15.36	.98	2.88	1.082	19.70	52.07	13.97	3.28	4.33	1.084	20.15
7	59.89	14.77	1.31	3.65	1.082	19.70	58.13	11.99	1.16	3.73	1.069	16.75
8	48.46	17.22	.95	2.94			55.23	13.88	2.44	3.97	1.084	20.15
9	61.19	12.54	2.12	2.58	1.070	17.00	58.00	13.24	1.85	3.45	1.076	18 35
10	58.02	17.38	.51	4.12	1.090	21.50	54.60	16.30	.40	3.80	1.085	20.40
11	57.25	16.89	.42	3.38	1.085	20.40	52.91	16.13	.59	4.87	1.088	21.05
12	55.58	17.40	.78		1.089	21.30	47.38	13.90	1.78	4.44	1 081	19.50
13	55.84	16.57	1.52	3.14	1.083	19.95	58.99	14.72	1.64	2.50	1.079	19.05
14	55.99	18.15	1.39	4.40	1.094	22.40	56.95	13.55	1.50	3 59	1.078	18.80
15	49.29	16.68	1.56		1.089	21.30	58.07	14.39	1.73	2.93	1.081	19 50
16	46.29	14.14	2.60	3.67	1.080	19.25	58.51	15.25	1.96	2.01	1.082	19.70
17	53.87	16.10	.94	4.20	1.085	20.40	58.75	15.60	1.20	3.47	1.085	20.40
18	57.97	15.78	1.26	4.01	1.083	19.95	65.80	12.41	2.57	1.81	1.069	16.75
19	55.99	15.77	1.72	4.23	1.084	20.15	60.34	12.44	3.02	2.63	1.075	18.15
20	51.72	15.91	1.27	3.66	1.082	19.70	62.71	9.45	1.58	2.31	1.053	13.05
21	57.28	14.55	2.31	3.11	1.079	19.05	67.31	4.64	4.77	2.61	1.048	11.90
22	57.98	16.22	1.66	4.17	1.088	21.05	56.11	10.19	2.46	3.28	1.067	16.30
23	63.72	11.70	4.14	2.74	1.071	17.20	59.73	6.50	3.98	2.97	1.052	12.80
24	56.77	16.35	1.20	4.15	1.085	20.40	64.03	7.27	1.07	3.14	1.045	11.15
25	52.94	14.86	1.50	3.27	1.082	19.70	60.39	12.15	1.92	1.96	1.071	17.20
26		13.50	1.43	3.34	1.078	18.80	59.51	11.69	1.28	4.00	1.066	16.10
Average	54.82	15.28	1.41	3.36	1.0814	19.57	58.09	12.91	1.82	3.49	1.0738	17.83

[1] Reproduced from U. S. Dept. Agr. Rpt. 1881–82: 459–460. Columns showing "Equivalent readings (° Brix)" have been added.

[2] See footnote 1 to Table 2, p. 17.

The effects of unfavorable conditions can not always be prevented, but very often it is possible at least to hold them to a minimum. Cultural practices as far as possible should be those that will promote steady and uniform development from the time the seed germinates until the stalks have reached the proper stage for harvesting, uniform growth being especially desirable during the time that the stalks are being formed. Furthermore, the grower should always take advantage of any signs indicating that the crop is about to undergo deterioration when approaching maturity. By promptly harvesting it may be possible to prevent losses of tonnage and save the quality of the sirup.

CULTIVATION

The cultivation of sorgo should be similar to that of corn; but the plants are smaller than corn plants of the same age, and it is necessary to take greater precautions against the growth of weeds and to exercise greater care to prevent the plants being broken. Usually there are many more sorgo plants in the row than there are corn plants. The purposes of cultivation are primarily to destroy weeds and to keep the soil open for the absorption of moisture.[7]

Cultivation should start soon after the plants are up, especially if there have been rains that would cause weed seed to germinate. Implements with a number of small shovels or teeth are more suitable for early cultivation than those equipped with larger shovels. They are less likely to cover or break the plantlets, and they leave the soil in better physical condition. It is sometimes possible to cross harrow the field with a spike-tooth harrow after the plants are through the surface, but on soils that have a tendency to crust after rains great care must be taken to prevent breaking the plants by the movement of the crusted soil. The early cultivation may be done with a weeder; with a light 1-horse harrow, harrowing with the rows; with a 1-horse cultivator; with a 2-horse, single-row cultivator; or with a 2-row cultivator. (Fig. 4.) These implements may be equipped with teeth, with small shovels of the type frequently called "bullock's tongue" shovels, or with other small shovels. Disk cultivators are also often employed with good results, and in some parts of the South the cotton scrapers are used when the rows are on ridges. Both shovels and disks should be set to work as close to the rows as possible without causing injury to the plants, and where cultivators with shovels are used they should be equipped with fenders to prevent covering and breaking the plants.

Cultivation may be somewhat deeper during early stages than later, as root development is then not extensive; but next to the rows deep cultivation should not be practiced and would be of little value, especially if the field was well prepared. In the middles the

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[7] Certain perennial weeds that require special treatment for their eradication grow abundantly in some localities where sorgo is cultivated for sirup making. Among these, Johnson grass and Bermuda grass are the worst. Johnson grass, belonging to the sorghum group of plants and being self-propagating by means of underground rootstocks, is very objectionable, because it provides a means for carrying over from one season to another fungous diseases and insect pests that attack sorgo. (See pp. 36–38.) Sorgo undoubtedly also crosses naturally with Johnson grass, and this sometimes causes a deterioration of seed stocks. For means of eradication of these grasses the reader is referred to the following publications:

TALBOT, M. W. JOHNSON GRASS AS A WEED. U. S. Dept. Agr. Farmers' Bul. 1537, 10 p., illus. 1928.

HANSEN, A. A. ERADICATION OF BERMUDA GRASS. U. S. Dept. Agr. Farmers' Bul. 945, 12 p., illus. 1923. Out of print, but may be consulted in libraries.

early cultivations may be deeper than next to the rows, and moderately deep cultivation may often be continued there without causing injury until the crop is about ready to lay by. This depends much upon the variety.

The cultivation may be level or the rows may be hilled or ridged. Weeds growing in the row may be effectively destroyed if the cultivator shovels are set so that they throw some soil toward the row. For this purpose a certain amount of hilling is justifiable. Hilling is also justified by some growers in that it promotes drainage of the field and gives the stalks a more secure anchorage, so that they can better withstand severe winds without becoming lodged.

In many cases hilling is carried to an extreme. The rows have a greater tendency to dry out during dry periods when hilled than when not hilled, and the cultivation is in general more expensive, especially if the ridges are made high. It is then necessary to make a separate trip across the field to cultivate each row and each middle;

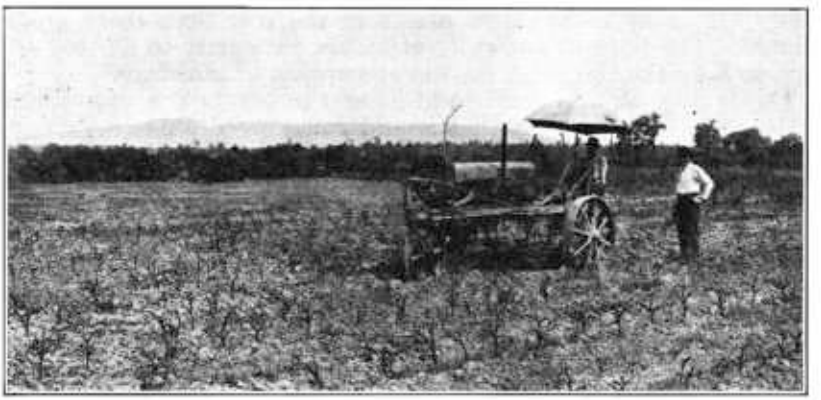

FIGURE 4.—A motor-driven 2-row cultivator

whereas, when the cultivation is level a man and team with a properly adjusted cultivator will cultivate at least a row and half a middle on each side at each trip across the field. Further, when the soil is shallow some subsoil is often thrown from the middles on the ridged rows at each cultivation, with the result that the fertility of the field is lowered to a certain extent.

The number of cultivations that can be given economically will vary with the time of the planting, the variety, the length of the season, and climatic conditions. On the average three to six cultivations will be needed to keep weeds in check. As sorgo grows more rapidly when planted late, fewer cultivations are then needed than for an early-planted crop. Early-maturing varieties grow more rapidly than late-maturing ones and shade the soil sooner. They therefore require fewer cultivations.

HOEING AND THINNING

Hoeing, while not always necessary, in many instances can not be avoided, in order either to destroy weeds growing in the rows or to thin the stand. Even when the seed is planted in hills it is not

always possible to regulate the planting so that just the desired stand will be secured, and when the planting is in continuous drills some thinning is necessary as a rule. The earlier the thinning can be done the better for the crop. The plants may be thinned at any time after they are about 2 inches high, and thinning should always be done before tillers are first put forth. The plants that are left then do not suffer so much, and thinning may be more easily and cheaply performed at that time. The plants are not so strongly rooted and the crowns are not so deeply covered as they are later. It is the custom with some growers to do the hoeing and thinning before the first cultivation. This is a good practice if the field is not unduly weedy. Some growers, however, prefer always to give a preliminary cultivation, barring off the row or turning the soil away from it, following this immediately with the hoeing. As hoeing removes some of the earth from the crown and roots, the field should be cultivated as soon as possible thereafter, in order to return soil to the plants to prevent rapid evaporation.

HARVESTING

TIME OF HARVESTING

The point in its development at which the crop should be harvested is one of the most important matters the grower has to decide and should be given careful consideration. The composition as well as the soundness of the stalks (and for that reason the quality and the quantity of sirup obtained) changes more or less with the progress toward maturity. After the stalks attain about their full size, maturity of the entire plant advances at about the same rate as the maturity of the head. The plants are generally considered mature when the seeds are hard. From the viewpoint of the sirup maker this is not always a good indication of maturity, as ripeness of the seed does not necessarily indicate ripeness of the stalk. These differences depend upon varieties and climatic conditions from one year to another. The stalks should be considered ripe when the largest yield of sirup of prime quality can be made from the juice, and this is partly determined by each of the following factors: The quantity of juice extractable; the percentage of solids contained; the ratio of sucrose to reducing sugars in the juice; the ease with which the juice can be freed from impurities (to a large extent determining the quantity of soluble solids that will be lost in the process of making the sirup, especially in home manufacture); and the soundness of the stalks. All of these factors change more or less with the advance in maturity of the plants.

The quantity of extractable juice varies less than the yield of stalks per acre or the percentage of sugars in the juice. This is especially the case when the stalks are ground in the type of mill commonly a part of the home outfit. The larger mills used by commercial factories, which usually consist of three units of three steel rolls each, are more efficient, and crops show greater differences in regard to the percentage of juice when ground in the factory mill than in a farm mill. The stalks, however, tend to become less juicy after they reach complete maturity (see Table 4, last two analyses), and there is a loss of juice in dry weather, the latter also being most apparent

after maturity. On the other hand, excessively humid seasons may cause increases in juiciness. In many cases differences in juiciness are not shown by the percentage of juice that is obtained. This is due to the fact that the total weight of the stalk is reduced by any drying that takes place and is increased in humid periods and that the stalks tend to become softer after they pass the mature stage, so that it is easier to crush out the juice.

In regard to composition, some sucrose is present in the stalks in the early stages of development. This as well as the percentage of total sugars and percentage of solids not sugar gradually increases, as is shown in Table 4, giving the averages of the analyses of about 45 varieties. The same is also in general true with regard to the ratio of sucrose to reducing sugars. It will be observed from the table that the highest content of sugars was reached some time after the seeds had become completely hard and that afterwards there was a decline.

TABLE 4.—*Composition of sorgo juice at different stages of development of the stalks*[1]

Stage of development of the crop	Analyses made in—				Average results, 1879, 1880, and 1881					
					Juice extracted and sugars and solids not sugar in the juice				Specific gravity of juice	Equivalent readings
	1879	1880	1881	Total	Juice extracted	Sucrose[2]	Reducing sugars[2]	Solids (not sugar)		
	No.	*No.*	*No.*	*No.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*		*° Brix*[2]
About 1 week before the panicle opened	------	58	16	74	60.41	1.57	3.86	1.89	1.028	7.05
Immediately before the panicle opened	2	69	38	109	62.26	2.32	4.03	2.05	1.032	8.05
Panicle just appearing	------	57	40	97	63.71	2.82	4.02	2.04	1.033	8.30
Panicle two-thirds out	------	70	52	122	64.34	3.35	3.94	2.33	1.035	8.75
Panicle entirely out; no stem above upper leaf	8	75	46	129	65.00	4.23	3.89	2.36	1.043	10.70
Panicle beginning to bloom at the top	4	62	51	117	65.17	5.16	3.88	2.58	1.045	11.20
Flowers all out; stamens beginning to drop	4	70	42	116	65.11	6.39	3.85	2.41	1.048	11.90
Seed well set	4	111	42	157	66.25	7.23	3.80	2.53	1.053	13.05
Seed entering the milk stage	4	266	45	315	65.15	8.74	3.26	2.44	1.057	14.00
Seed becoming doughy	8	217	60	285	65.49	9.69	2.76	2.50	1.060	14.70
Seed doughy; becoming dry	12	166	53	231	65.22	10.53	2.50	2.72	1.062	15.15
Seed almost dry, easily crushed	10	170	44	224	63.19	11.41	2.19	2.84	1.066	16.10
Seed dry, easily split	8	183	40	231	62.90	11.75	2.09	2.82	1.068	16.55
Seed split with difficulty	8	191	37	236	61.26	12.13	1.92	2.95	1.068	16.55
Seed split with more difficulty	4	217	37	258	60.90	12.09	1.87	3.11	1.068	16.55
Seed split with still more difficulty	6	339	40	385	61.10	12.79	1.65	3.28	1.071	17.20
Seed harder	6	197	37	240	59.98	14.07	1.57	3.92	1.078	18.80
Seed still harder (1)	2	191	45	238	61.03	12.80	1.71	3.34	1.071	17.20
Seed still harder (2)	12	30	44	86	56.74	14.01	2.18	3.31	1.080	19.30
Seed still harder (3)	22	------	370	392	58.45	11.95	1.72	3.81	1.069	16.75
Total	124	2,739	1,179	4,042	------	------	------	------	------	------

[1] Reproduced from U. S. Dept. Agr. Rpt. 1881–82: 452. The right-hand column, giving specific-gravity equivalent in Brix hydrometer readings, has been added.
[2] See footnote 1 to Table 2, p. 17.

With reference to sirup quality, it should be noted that after reaching maturity the stalks tend to degenerate, and that when the crop is harvested and made up after such degeneration has commenced the sirup is almost invariably of stronger flavor and darker color than when the crop is harvested and made up at the proper time. Only a slight deterioration in a part of the stalks may affect

both flavor and color. On the other hand, in cases where the stalks are harvested young, it is often difficult to free the juice from natural impurities which, if not eliminated, tend to impart objectionable flavors and colors. Some sirup makers are proficient in eliminating impurities from the juice of even comparatively young stalks. When this object is accomplished the sirup is as a rule milder and lighter in color than sirup made from older stalks.

In order to determine sweetness some growers resort to tasting the stalks. Nothing but a very rough estimate can be arrived at in this way—owing partly to the presence of three kinds of sugar,

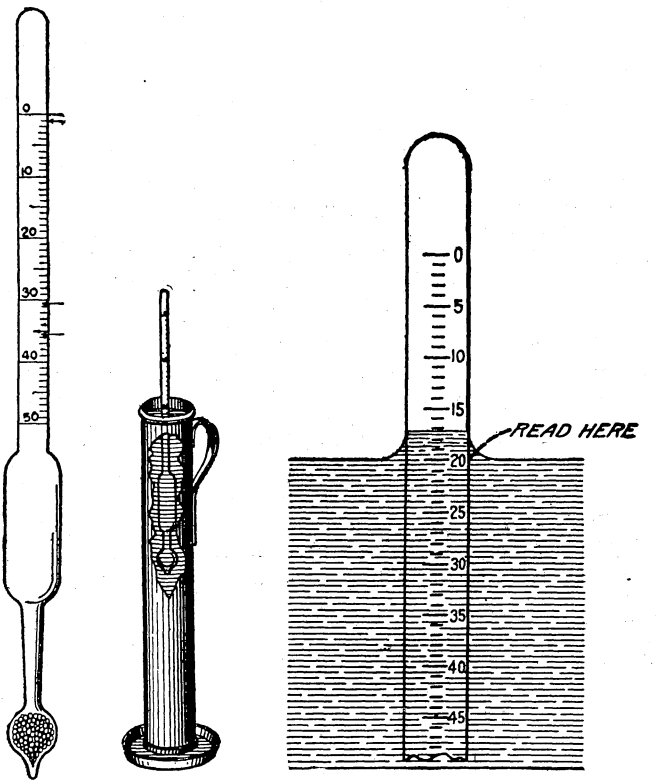

FIGURE 5.—A hydrometer, showing the instrument suspended in a cylinder of juice and the point on the scale at which the reading should be made

varying in proportions at different stages of development of the crop and possibly to a certain extent under different conditions of growth—but many growers are able to judge with considerable accuracy when the proper time for harvesting has been reached simply from the appearance of the crop, considered from the viewpoints of both quantity and quality of the product. A more accurate method is from time to time to take samples of stalks from the field and to determine the density of juice expressed from them by means of a hydrometer. Figure 5 is an illustration of a hydrometer. The density of the juice, not its actual sugar content, is indicated by the hydrometer, but density and sugar content are closely correlated,

and the method is reliable enough to be of considerable value. With a little practice a grower or sirup maker can become proficient enough in the use of the hydrometer for ordinary purposes.

In taking the samples care should always be exercised to have them as nearly as possible representative of the entire field. The stalks should be gotten at random and should be of average size and in average stage of development. A sample large enough to be fairly representative of the field as a whole should be taken. An effort should be made to have the proportion of tillers to initial stalks correspond with that of the entire field. If possible, the sample should be passed through a mill immediately after having the leaves removed and being cut. The expressed juice should then be strained, in order to remove the coarser substances floating or suspended in it, after which it should be tested in the following manner: A tall cylinder is filled and the hydrometer floated freely in it. When the latter comes to rest the reading on the scale at the surface of the juice is noted. (See scale at right in fig. 5.) This reading indicates the density.

There are a number of kinds of hydrometer. The Baumé hydrometer, which is very commonly used for rough sugar work, is graduated in degree from zero to 50. Table 5 shows the approximate percentages of water and of dry matter in solution when the readings on the Baumé scale are made at the standard temperature, 63½° F. As the substances in solution consist mainly of sugars, with only small quantities of other substances, all of which become a part of the sirup when the juice is concentrated by boiling, the density determined in this way is a rough indication of the yield of sirup that may be expected. Juice that shows a density of 11° Baumé at the temperature of 63½° should be considered very good. The juice of many varieties will, in fact, not reach that point during the entire season; 9° or 10° Baumé is as high as can be expected from a large number of varieties, and the grower will need to learn from experience with the variety he cultivates the maximum density that may be expected.

TABLE 5.—*Dry substance and water corresponding to each degree Baumé*

[The figures in the "Dry-substance" column correspond to the figures for degree Brix given in Tables 2, 3, 4, 6, and 7 of this bulletin]

Degrees Baumé [1]	Dry substance	Water	Degrees Baumé [1]	Dry substance	Water	Degrees Baumé [1]	Dry substance	Water
	Per cent	*Per cent*		*Per cent*	*Per cent*		*Per cent*	*Per cent*
1	1.7	98.3	18	32.1	67.9	35	63.9	36.1
2	3.5	96.5	19	33.9	66.1	36	65.8	34.2
3	5.3	94.7	20	35.7	64.3	37	67.8	32.2
4	7.0	93.0	21	37.5	62.5	38	69.7	30.3
5	8.8	91.2	22	39.4	60.6	39	71.7	28.3
6	10.6	89.4	23	41.2	58.8	40	73.7	26.3
7	12.3	87.7	24	43.1	56.9	41	75.7	24.3
8	14.1	85.9	25	44.9	55.1	42	77.7	22.3
9	16.0	84.0	26	46.8	53.2	43	79.7	20.3
10	17.7	82.3	27	48.6	51.4	44	81.8	18.2
11	19.5	80.5	28	50.5	49.5	45	83.8	16.2
12	21.3	78.7	29	52.4	47.6	46	85.9	14.1
13	23.0	77.0	30	54.3	45.7	47	88.0	12.0
14	24.8	75.2	31	56.2	43.8	48	90.1	9.9
15	26.6	73.4	32	58.1	41.9	49	92.2	7.8
16	28.4	71.6	33	60.0	40.0	50	94.4	5.6
17	30.3	69.7	34	61.9	38.1			

[1] Taken at 63½° F.

STRIPPING OFF THE LEAVES AND REMOVING THE HEADS

When the crop is made up with a farm outfit, stripping off the leaves should be the first operation of the harvesting. A field of stripped sorgo is shown in Figure 6. The leaves should be removed on account of the large amount of undesirable matter contained in them, especially green chlorophyll, which occurs in all green plants. For home manufacture the stripping should be done while the stalks are standing. The leaves may be struck off with a paddle, or with the cane knife that is used for cutting, or pulled off with the hands. Special stripping tools, such as are sometimes used for stripping sugarcane, are not generally in favor for stripping sorgo. The bases of the leaves, or leaf sheaths, cling tightly around the stalks, not being shed off like those of many varieties of sugarcane, and can not readily be removed. These leaf sheaths remain, therefore, except in cases where growers clean them off with a knife, which is a slow process and not often followed. All branches as far as possible should be removed.

Commercial companies usually purchase the stalks unstripped. The leaves are removed by machinery just before grinding. In some factories the process consists of cutting the stalks with leaves attached into short lengths by means of a power-driven knife, and then agitating the mass of pieces of stalks, leaves, and leaf sheaths before a current of air. The leaf sheaths are more thoroughly eliminated in this way than can be done by stripping in the field.

In some instances stalks have been ground without stripping, and growers have reported success from this procedure. Greater evaporating capacity than is ordinarily employed is advisable when this procedure is followed, in order to afford greater opportunity for skimming off impurities.

The leaves, even when partly dried, contain extractable juice or sap which contains sugar. A sample of leaves passed separately through a 3-roller mill yielded 18.07 per cent of juice which showed a density of 10.67° Brix, and two varieties tested with and without leaves gave results as shown in Table 6, in which it will be noted that in the case of both varieties approximately 2 per cent more juice was obtained from the unstripped than from the stripped stalks. The percentage of sugars was somewhat less in the juice from the unstripped stalks, but the difference is negligible from a sirup-making standpoint. One investigation indicated 15.8 per cent more juice and 3.1 per cent more sirup from stalks not stripped than from stripped stalks, but it appears from the results of the recent tests that in general additional sirup obtained would not be sufficient to be significant.

A certain amount of sugar would be lost in skimming off additional impurities introduced with the leaf sap, although when the plants are past mature, especially if the leaves have been withered by frosts, the quantity of undesirable matter pressed out would be smaller than earlier in the season. The important point, however, especially for the small producer, is that stripping requires much time and adds to the expense of harvesting. If sirup of good quality can be produced from unstripped stalks it is an advantage from the viewpoint of economy.

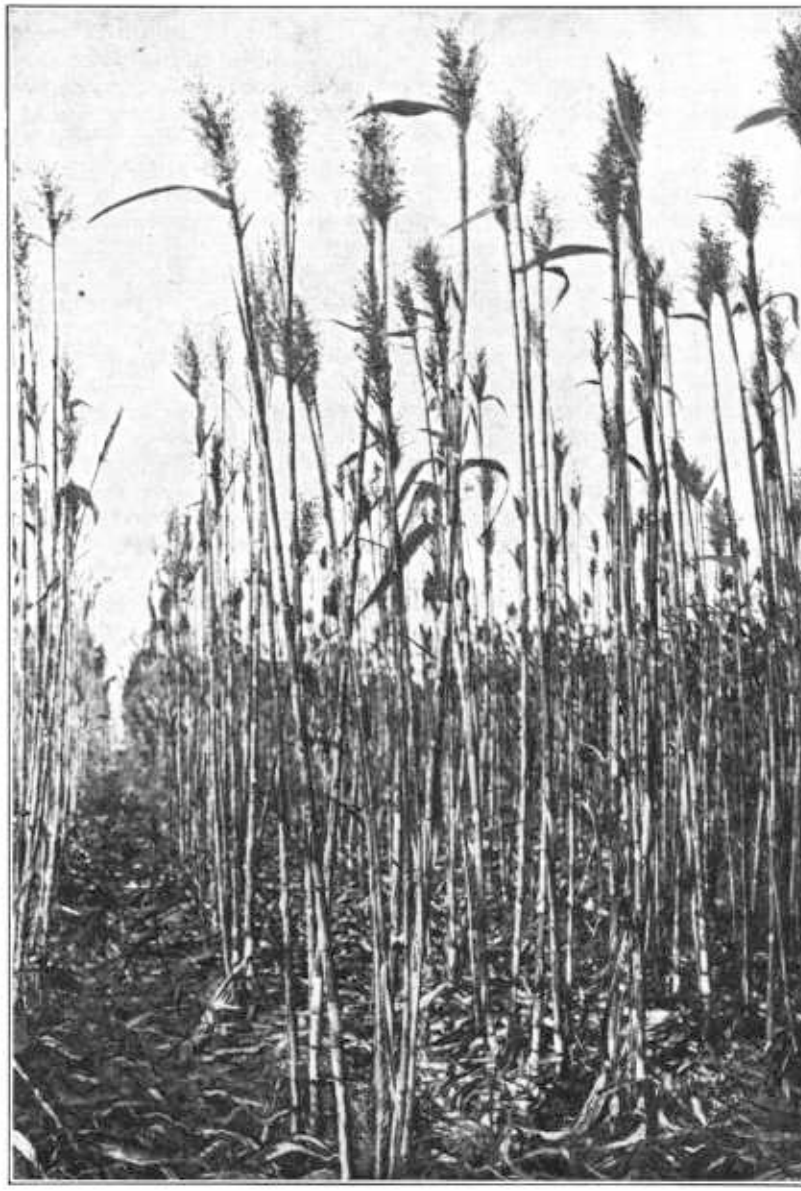

FIGURE 6.—A field of sorgo plants stripped for grinding

TABLE 6.—*Analyses of the juice of two varieties of sorgo stripped and unstripped*

Variety	Juice extracted	Density of juice[1]	Sugars in the juice			Total sugars ÷ Brix[1]
			Sucrose[1]	Reducing sugars[1]	Total sugars[1]	
	Per cent	*°Brix*	*Per cent*	*Per cent*	*Per cent*	
Jones (stripped)	50.18	19.35	13.14	2.80	15.94	82.4
Jones (not stripped)	52.23	18.20	11.75	2.84	14.59	80.2
White African (stripped)	48.36	21.30	14.33	2.45	16.78	78.8
White African (not stripped)	50.50	20.65	13.60	2.54	16.14	78.2

[1] See footnote 1 to Table 2, p. 17.

Sorgo seed contains large quantities of starch as well as other impurities. All heads, including those that have not emerged, should be removed. They may be cut off with a knife while the stalks are standing, but if the stalks are left in piles with the heads all in one direction the heads can be removed more easily. When the crop is made up in a factory the heads in most cases are removed after the stalks have been received and just previous to the grinding. This operation is often performed by means of some mechanical appliance. (Fig. 7.)

There is sometimes uncertainty in the minds of growers as to how much, if any, of the top of the stalk should be cut off with the head. The last internode or peduncle generally contains less soluble solids than the remainder of the stalk. A test (Table 7) showed a lower percentage of juice as well as a lower percentage of soluble solids in each of three varieties in the case of the peduncles than in the remainders of the stalks. The averages were as follows: Average extraction of juice from peduncles, 45.26 per cent; from the remainders of the stalks, 55.68 per cent; average solids in juices from peduncles, 11.35 per cent; from the remainders of the stalks, 15.24 per cent. Of more importance is the fact that the peduncle and the adjoining internodes frequently deteriorate before the remainder of the stalk shows any sign of deterioration. Juice from these parts is then dark and more or less ill flavored. When there has been deterioration in these parts it is advisable to remove the entire peduncle and the affected internodes as well.

At one time it was thought that if the heads were removed before maturity it had a tendency to increase the proportion of sugar in the stalk; but results of a number of experiments have shown that although the maturity of the plant is advanced by removing the head the maximum quantity of sugar that ultimately would be obtained is not increased.

CUTTING

Small areas grown for a home supply of sirup are usually cut by hand. A corn knife or one of the types of knife employed in the Gulf States for cutting sugarcane is used. Large acreages are also sometimes harvested in this way. As the stalks are cut they should be laid in or across the rows, preparatory to being hauled. When three or four men are working together, the cutting and the loading upon wagons, if desired, can be done simultaneously. A hoe

then can be used to advantage for the cutting, one man operating the hoe and the others grasping bunches of stalks as they are cut and loading them on the wagons, which are driven along just outside the row that is being cut.

FIGURE 7.—Rotating saws used for removing heads from sorgo stalks

The corn harvester (fig. 8) can often be used to advantage for cutting large fields, unless the stalks have lodged badly. Some growers remove the binder attachment, so that the stalks are thrown off in bunches but are not bound. Other growers think it advantageous

to have the stalks bound, for sake of convenience in handling. The common sled corn cutter is also sometimes used for the cutting, being operated the same as when cutting corn.

As a usual thing, unless deterioration has taken place it is advisable to cut the stalks close to the surface of the ground, as when they are cut higher there is a loss of tonnage, and an increased amount of stubble is left on the field; but if considerable deterioration has taken place in the bases of the stalks, or if there has been considerable growth of aerial roots at the bases, it is better to cut high enough to leave the discolored or rooty portions, else it will be necessary to remove these afterwards to prevent lowering the quality of the sirup.

The lower internodes of the stalk as well as the upper internodes frequently contain smaller quantities of juice and smaller quantities of soluble solids extractable than the internodes in the middle of the stalk. This, it will be noted, was the case in the tests reported in Table 7, in the making of which a 3-roller power-driven mill was used. With each variety smaller quantities of juice and of soluble solids were obtained from the lower internodes, as well as from the

FIGURE 8.—Cutting sorgo with a corn harvester. The variety is Red X

upper ones, than from those in the middle. The analyses of the first two varieties were made after the seed had become hard; in the case of the third the seed was in the milk stage. The probable explanation of the points brought out is that the basal internodes are the oldest and those at the top the youngest, the internodes tending to reach maturity in the order that they were formed. It is sometimes found that the lower internodes have commenced to deteriorate some time before the internodes in the middle and those above the middle show signs of deterioration, due to the fact that they are older.

The lower internodes are as a rule also shorter than those in the middle, the proportion of nodes to internodes being consequently greater at the base. It appears from tests made that the nodes contain less sugar and more impurities than the internodes, this being shown in Table 2 giving separate analyses of the nodes and internodes of three varieties. On this account the juice from the bases often contain less sugar and more impurities than juice from the middle internodes.

TABLE 7.—*Percentages of juice and of solids in solution from different parts of the sorgo stalk*

Variety	Three lower internodes		Middle internodes		Three upper internodes		Peduncles	
	Juice extracted	Density of juice[1]	Juice extracted	Density of juice[1]	Juice extracted	Density of juice[1]	Juice extracted	Density of juice[1]
	Per cent	*°Brix*	*Per cent*	*°Brix*	*Per cent*	*°Brix*	*Per cent*	*°Brix*
Red X	49.18	20.26	54.13	20.36	47.82	19.83	43.54	14.71
Sapling	52.19	17.27	57.77	16.66	53.84	14.26	44.87	10.47
Indiana Amber	60.49	9.48	63.72	9.56	62.05	9.53	47.36	8.86
Average	53.95	15.67	58.54	15.53	54.57	14.54	45.26	11.35

[1] See footnote 1 to Table 2, p. 17.

HANDLING THE CROP

In case the crop is harvested without being stripped, it should be allowed to remain in the field for a time, so that the leaves may partly cure; otherwise some fermentation and heating is liable to take place

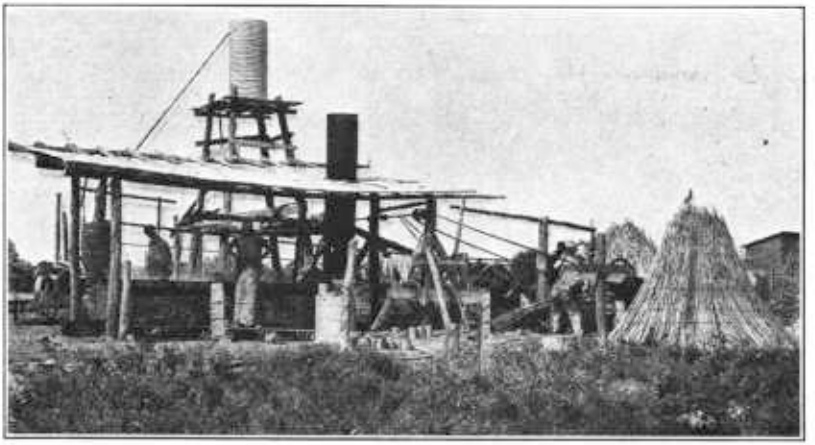

FIGURE 9.—A farm sirup-making outfit, showing sorgo stalks in shock for grinding

in the foliage after the stalks are hauled from the field and put into shocks or piles preparatory to grinding. This is especially liable to occur if the weather is warm. Some growers think it also advisable to allow stripped stalks to cure to a certain extent after being cut and before they are passed through the mill; but as a general rule the crop should be made up within a few days. Some deterioration will take place in mature stalks if they are not soon ground, and there will be a loss of moisture and a consequent loss in weight, especially if the stalks are not sound and have not been well shocked or piled. (Fig. 9.) The loss will become evident not only in the weight of the stalks but also in the percentage of juice extracted. There may be an increase in the percentage of sugars in the juice, due to concentration as a result of the drying out of the stalks; but eventually the amount of sugars that can be gotten out, and for that reason the quantity of sirup that can be made, will be reduced.

Shocking, if done early enough, tends to retard, though it does not entirely prevent, natural deterioration of the stalks in the field due to senescence, or aging. It also to a great extent prevents rapid deterioration of partly mature stalks after severe frosts. In case the crop can not be made into sirup immediately, because of the demands of other work, it is sometimes cut and shocked in the field and is made up when opportunity is afforded. Shocking in the field is, however, not generally a good practice. Some deterioration takes place in shocked stalks, especially in warm weather, the percentage extraction of juice is lowered, and the expense of harvesting is increased. The advisability of shocking will depend on the ability of the variety to withstand deterioration, the condition of the crop, and the probability of frosts.

For hauling, low wagons, preferably with broad wheels and broad, flat beds extending over the wheels (fig. 10), are better than ordinary wagons equipped with ordinary beds or with hayracks. When the

FIGURE 10.—Loading a wagon with sorgo stalks. The variety is Red X

haul is a long one, motor trucks can often be used to advantage. Large 2-wheeled dump carts are employed for hauling sugarcane in the Tropics, the dumping feature saving the labor of unloading; and similar carts might be used to advantage for hauling sorgo.

Commercial companies sometimes make use of the railroads as a means of transporting harvested stalks from distant farms to the factory. Derricks are then often used to unload the wagons at the railroad stations and the railroad cars at the factory. (Fig. 11.) To facilitate unloading with derricks each wagon is equipped with a rope sling, which is placed in the bottom of the wagon and the stalks loaded upon it, the sling remaining around the wagonload of stalks until unloaded at the factory.

CARE OF THE SEED

As a general rule, more seed is produced than the grower needs for his own planting, although this is not always the case. Dry

weather coming in the latter part of the growing season sometimes entirely prevents the production of seed, early frosts ruin heads that have not reached approximate maturity before severe frosts occur, and the sorghum midge (p. 38) often seriously reduces the seed crop in the Southern States. Seed saved for planting should be given special care to insure its purity and high viability. Only well-matured heads selected from the field before harvest should be retained, and these should be carefully cured, so that not only the seed but also the peduncles, axes, and branches of the heads become dry. This may be done (1) by spreading the heads upon a floor that is not roofed over, or upon a level or nearly level roof of a building; (2) by tying them in bunches and hanging in a dry, airy place, preferably under shelter; (3) by putting them loosely in gunny sacks and hanging these in a sunny, airy place; or (4) by subjecting them to artificial heat in a drier.

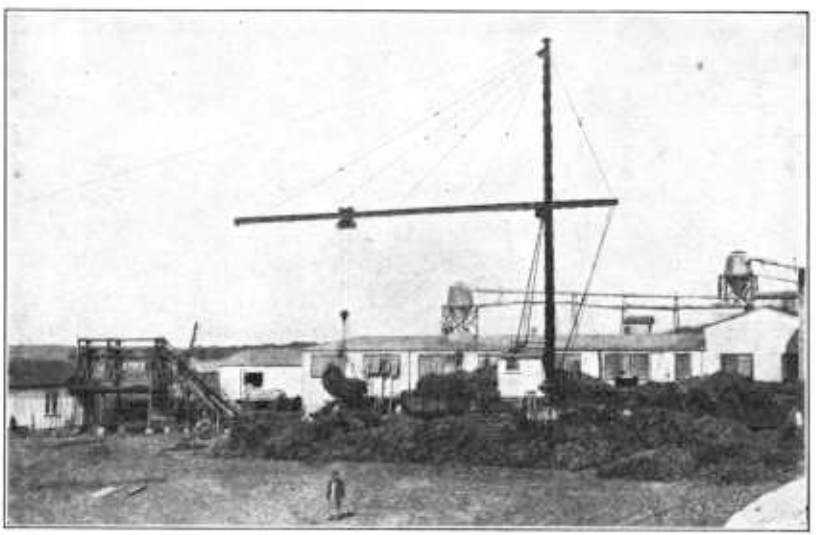

FIGURE 11.—Unloading sorgo from railroad cars by means of a power-operated derrick

Seed not selected in the field will vary considerably in quality, owing partly to the fact that ordinarily the crop is harvested before all the heads are completely ripe. Much of it may be used for planting. The better heads may be selected, threshed separately, and used or sold for planting, being especially adaptable for forage purposes. Sometimes much of the seed is only in the hard-dough stage when the crop is harvested. Such seed requires greater care in handling to prevent loss of vitality and is more difficult to cure. When well cured it will often show a good percentage of viability in germination tests.

In the warmer sections of the United States it is better to thresh the seed in the fall, so that it can be protected from grain weevils and grain moths during the winter. An ordinary grain thresher may be used when seed is produced in large quantities, but usually it is necessary to make adjustments in order to prevent breaking the seed. The speed of the cylinder may be reduced, and it is

often advisable to remove some of the concave teeth. Seed saved for planting may be beaten out with a flail or with an ordinary stick, or raked out by drawing the heads across a row of spikes projecting close together from a plank or board; and the chaff may be removed by passing the seed through a fanning mill, by fanning it by hand, or by letting it fall on a sheet while the wind is blowing. Factories sometimes have small threshing machines especially made for threshing seed for planting. Where seed is produced in considerable quantities such a threshing machine and a fanning mill are serviceable.

After threshing, the seed should be thoroughly cured by aeration. This may be done by spreading it on a cement floor under shelter and turning it occasionally. Artificial driers are also sometimes used. It should then be put into containers. Carbon disulphide at the rate of about 4 to 6 pounds for each 1,000 cubic feet of space should be put into a small open vessel near the top of each container for fumigation purposes. It should be inclosed tightly. Carbon disulphide is a volatile liquid. The gas evolved, being heavier than air, will settle to the bottom, destroying weevils or grain moths present or that hatch out from eggs on the seed.

YIELDS OBTAINABLE

Crop yields vary greatly, not only on account of differences in fertility of fields and differences in the character of seasons, but also with the variety. For this reason it is impossible to state with accuracy what weights of stalks and of seed and yields of sirup may be expected. In general, the yields of stalks correspond with the length of the growing period, although there are a few early-maturing varieties that give yields as good as or better than some of the midseason varieties. For early varieties under average conditions 8 to 10 short tons per acre—total weight of stalks, heads, and leaves—may be considered a good yield; for medium varieties 10 to 12 tons; and for late varieties 12 to 16 tons. For one of the early-maturing varieties an acre yield of 23 tons has been reported, and 32 tons for one of the late-maturing varieties.

The proportions of heads and leaves vary greatly with the variety, with the stage of development, and with climatic conditions. The heads make up from 10 to 30 per cent and the leaves from 15 to 35 per cent of the weight of freshly harvested plants. Except where the leaves have been withered by frosts, the leaves and heads together probably constitute an average of 25 to 35 per cent of the total weight of uncured plants when in the proper stage for harvesting. The weight of the leaves and the ratio of the weight of the leaves to the total weight of the plant decrease rapidly after frosts, as well as in dry periods of weather. After cutting, the entire plant loses weight, the loss from the leaves being more rapid than from either the stalks or the heads.

Well-filled heads should thresh out 40 to 70 per cent of seed. Fifty per cent is a good average for a large number of varieties, though this will be exceeded by well-selected heads of certain varieties. The seeds will often lose some weight after threshing, but if the heads are well cured before threshing the loss will not be great.

Stalks after having had the leaves and heads removed should yield 40 to 60 per cent of juice, by weight, when passed through a 3-roller mill. Some sirup makers believe that in order to obtain sirup of highest quality the stalks should not be pressed hard enough to produce a high extraction of juice. It is thought that smaller quantities of impurities are then pressed out. This belief has not been definitely verified experimentally, and the large mills used by commercial factories, consisting of three units of three rollers each, sometimes give an extraction as great as 65 or 75 per cent of juice, as compared to the weight of stripped stalks. If the extracted juice has a density of 10° Baumé at a temperature of 63½° F., it indicates as shown by Table 5, that 82.3 per cent of the juice is water and that 17.7 per cent is solid matter, the latter being mainly sugars. From this it may be computed by the use of a table [8] that it would require 5.3 gallons of this juice to make a gallon of sirup having a density of 40° Baumé, providing no losses of soluble solids in the skimming or other defecating or purifying process occurred. Assuming an acre yield of 12 tons of stripped stalks and a 75 per cent extraction of juice having a density of 10°, it may be determined that approximately 375 gallons of sirup, having a density of 40°, would be obtained. Acre yields and the percentage of loss in the skimmings and elsewhere in the process of manufacture vary greatly, and figures obtained by the United States Department of Agriculture indicate that the average acre yield in the United States in 1928 was but 77.5 gallons of sirup.

The average yield of sirup per ton of sorgo stalks in the United States increased from 8.9 gallons in 1899 to 13.1 gallons in 1919, according to census estimates, but with proper methods of harvesting, handling, and manufacture a grower should obtain at least 16 gallons of sirup having a density of 38° or 40° Baumé from each ton of stripped stalks of the better varieties, better results than these often being obtained.

UTILIZATION OF SORGO SIRUP AND THE BY-PRODUCTS OF MANUFACTURE

Sirups made from sorgo juice have a value for table and culinary purposes not possessed by some other sirups. Brown bread, cookies, pies, and baked beans are articles of food in the preparation of which sorgo sirup is used, certain kinds of confections also being made from it. Sirup made on farms is sometimes purchased by buyers for commercial concerns, which put it on the market either in its pure state or as a mixed product; but more commonly the farm-made sirup is utilized in the locality where made. Sirup made by factories is sold either pure or mixed with other sirups. Sorgo sirup adds flavor and color to the mixed product, and the mixture is generally lighter in color than the sorgo sirup used as an ingredient.

The by-products of the crop are the seed, leaves, bagasse, head straw, and skimmings. Sometimes also there are waste stalks, which are readily eaten by livestock of all kinds. Commercial factories sometimes have small quantities of second-grade sirup. These by-products have a value and may be used or sold.

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[8] SPENCER, G. L. A HANDBOOK FOR CANE-SUGAR MANUFACTURERS AND THEIR CHEMISTS. Ed. 7, 560 p., illus. New York and London. 1929. (See pp. 471–475.)

Seed of any of the superior varieties not needed for the grower's own use, if pure, true to name, and of high viability, should find a ready market and bring a good price for planting purposes. In addition to its use for planting, the seed has a value as feed for poultry and other livestock. It is sometimes ground and used as an ingredient of mixed stock feed. Until recently it has been considered inferior to corn as a stock feed and somewhat less palatable, due to tannin contained; but recent experiments indicate that if ground and fed in a liberal grain ration, together with a liberal ration of alfalfa hay and silage, it is equal to corn chop in maintaining body weight or milk production of dairy cows and equal or superior to corn chop for the production of butterfat. It also appears as a result of these experiments that there is no difference as to the palatability of ground sorgo seed and corn chop when fed in the manner here described.

The leaves, if well taken care of, have a high value as roughage. They may be fed fresh or cured and stored, as preferred. After

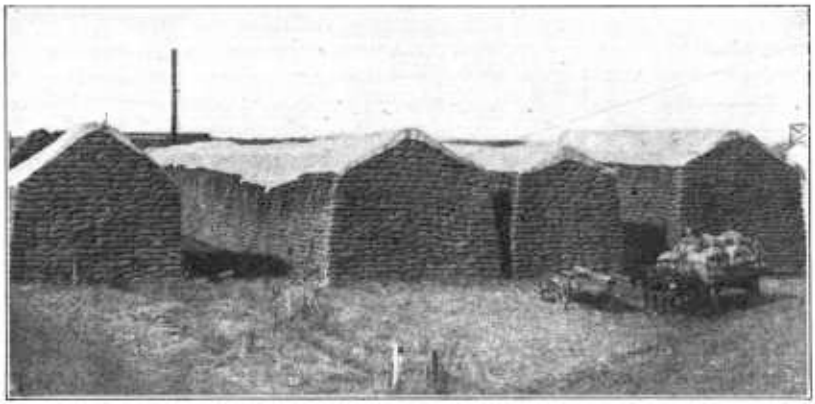

FIGURE 12.—Ground sorgo bagasse in bags ready for shipment

being cured they may be baled and sold. They are also sometimes ground into meal. In some cases the fresh leaves are put into silos either separately or in conjunction with the crushed stalks. The silage obtained is usually of good quality and its composition makes it valuable as roughage.

The remains of stalks after they have passed through a mill are called bagasse—sometimes incorrectly called pomace. (Fig. 12.) Bagasse may be used for fuel, commercial factories often having furnaces especially equipped for burning it. Other uses are the making of a building material called wall board, as a filler for prepared stock feed, and as bedding for cattle.

The straw and chaff that remain after threshing the heads, especially in cool weather, will to a large extent be eaten by livestock if they are allowed access to the stack.

Skimmings may be fed to hogs or to cattle. Frequently the skimmings are rich in sugars, and their feeding value is high. Low-grade sirup not suitable for table or culinary uses has value as feed, on account of the sugars contained. It is sometimes used in the

preparation of mixed stock feeds. Both skimmings and waste sirup are also occasionally used for making vinegar.

SORGO DISEASES

Sorgo grown for sirup production is attacked by certain fungous and bacterial diseases, as well as by certain insect pests; but from reports of the United States Plant Disease Survey, covering the entire area of sorgo production, it does not seem that as yet diseases play a very important rôle in limiting production. The seed crop, however, is sometimes damaged considerably by smut. In commercial production, sorgo diseases are largely disregarded, special control measures not having become a part of general crop practices; but since some of the diseases may at some time become more seriously destructive, it is well for growers to become familiar with them.

STRIPE

The most conspicuous disease of sorgo is a bacterial disease called stripe.[9] This occurs on various sorgo varieties as well as on related grasses. In this disease extensive streaks or blotches occur on the leaf blades and leaf sheaths. The color of these streaks or blotches varies with the variety, ranging from amber color to a deep purplish or orange red.

At present, evidence is not at hand to show that this disease seriously affects yields, and as experimental work has given some evidence of differences in resistance among varieties, should it at any time become serious in particular localities, progress in control could doubtless quickly be made by the utilization of resistant types.

LEAF-SPOTTING DISEASES

Diseases of the leaf-spot type, called anthracnose[10] and leaf spot,[11] each year cause some losses, by reason of their effects upon the leaves. This varies with the season. Losses range from 1 to 5 per cent in wet seasons in some areas. No specific control measures have been tested for diseases of this type, and growers must rely upon the general practices of good crop growing. This is also true of leaf rust,[12] which is of general occurrence in the southern districts and occasionally causes some losses. It is not possible to make any specific recommendations for this disease.

SORGHUM SMUTS

The sorghum group of plants is attacked by three smuts, head smut,[13] loose kernel smut,[14] and covered kernel smut.[15] Head smut, as its name implies, involves the entire panicle or head, this being converted into a spore mass protected by a transient, whitish membrane. In general appearance this disease resembles the well-known smut of corn. It is not very abundant and, so far as sirup sorgos are concerned, is not of great importance.

The loose kernel smut of sorgo stunts the affected plants, and instead of sound kernels of seed numerous smut balls are produced in the head. These have very fragile inclosing membranes which soon break, and the head thus is converted into a black, smutty mass. This disease apparently does not cause appreciable damage in the United States.

Covered kernel smut is the most destructive of the smut diseases attacking sorgo. It is a typical kernel smut, the individual flowers being involved and converted into false kernels or smut balls, inclosed in a membrane, which is fairly tough and may persist until ruptured by threshing. The smut powder from the smut balls may be carried by the wind and some of it light on the

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[9] *Bacterium andropogoni* EFS.
[10] *Colletotrichum lineola* Corda.
[11] *Cercospora sorghi* E. and E.
[12] *Puccinia purpurea* Cooke.
[13] *Sorosporium reilianum* (Kühn) McAlpine.
[14] *Sphacelotheca cruenta* (Kühn) Potter.
[15] *Sphacelotheca sorghi* (Link) Clinton.

sound kernels. In this way material for infection of the succeeding crop is furnished, the infection of the young seedlings taking place soon after the seeds germinate. The disease, for this reason, is amenable to control by some form of seed disinfection. Formaldehyde seed treatment has been recommended as a result of experiments. The seed should be soaked, preferably for about one hour, in a solution consisting of 1 pint of commercial formaldehyde in 30 gallons of water. It should be planted soon after receiving this treatment. Recent experiments have shown that the copper-carbonate seed treatment used to control stinking smut of wheat or treatment with sulphur dust will control covered smut of sorghum. About 2 ounces of either high-grade finely ground copper carbonate or flowers of sulphur are thoroughly mixed with the seed before planting. Copper carbonate is a poison, and care must be taken in its use. Should this smut disease become serious, one of these treatments should be used to control it.

It is not known that any of the smut diseases seriously injure the sorgo stalks for sirup making, except that they often retard growth, resulting in stunted plants and consequently reduced yields. The principal damage is the loss of the seed. The injury is therefore of less importance than it would be if the seed were of primary commercial importance.

There is some evidence to show that sorgo may be attacked by the same types of root-rot fungi that have proved so injurious to corn. So long as crop rotation is adhered to, growers are safeguarding against intensification of many types of disease. Because of this, crop rotation is very important from the viewpoint of disease control. Coupled with this, considerable gain will accrue from the utilization of varieties that are disease resistant. Care in the selection of suitable varieties means greater emphasis upon seed stock quality, which will result in greater care in seed selection and the avoidance of seed-borne diseases.

INSECTS INJURIOUS TO SORGO [16]

The sorghums as a rule are not severely damaged by insects, although a number of the general grass feeders may occasionally become so abundant as to be very destructive. Among these the chinch bug, cutworms, grasshoppers, the corn earworm, and others have long been familiar pests, and in most cases control measures are generally known. The following brief descriptions include several species of insects that may be considered of especial interest in sorgo production.

THE SUGARCANE MOTH BORER [17]

In the production of sorghum in the southern parts of Texas, Louisiana, Mississippi, and Florida the sugarcane moth borer is likely to be encountered. This is a "worm" about an inch in length when full grown and will be found in tunnels in the stalks. The adult of the borer is a straw-colored moth which deposits its eggs on the leaves of the plants. The small larvae which emerge first feed a little on the leaves, and then make their way into the interior of the stalks, where they pass the rest of the larval stage and all of the pupal stage. The resulting moth makes its way out of the stalk through a hole partly cut for it by the larva before pupating.

The damage to the stalk often results in the dying of the upper leaves and the whitening of the seed cluster. A heavy infestation would result in a decrease in the quantity and the quality of the sirup manufactured. Fortunately, however, sorghum is not a favorite host plant of the sugarcane moth borer. In the infested districts sorghums should be planted as far as possible from fields of sugarcane and corn, and care should be taken to destroy at some time during the winter all larvae hibernating in stubble and pieces of the stalks.

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[16] Prepared in the Bureau of Entomology.

[17] *Diatraea saccharalis crambidoides* Grote.

THE SORGHUM MIDGE [18]

The sorghum midge occurs in the South-Central States. It is a very small 2-winged fly which deposits its eggs in the glumes at blossoming time. The maggots which emerge feed on the developing seeds, thus destroying them. It has been found that Johnson grass affords the midge a suitable food plant on which to pass the winter, and the recommendation has therefore been made to destroy grasses in the vicinity of fields that are to be planted to sorghum. For the production of a limited quantity of seed, the seed clusters can be bagged to prevent midge infestation. The fumigation of the gathered seed and the cleaning of the fields of bits of sorghum and grass during the winter have been recommended.

THE CORN-LEAF APHIS [19]

This green aphis, common on corn, also occurs on sorghum. It is found on the leaves, from which it sucks the juice. Its principal injury is due to the fact that it is a carrier of the sugarcane mosaic disease, which occurs in the sugarcane-growing sections of the South; this disease also attacks sorgo. It is desirable, therefore, to plant sorghum in these sections at some distance from fields of corn, sugarcane, and infested grasses.

THE FALL ARMY WORM [20]

The fall army worm is a striped caterpillar, practically hairless and about 1½ inches in length when full grown. It appears during a wet spring along the Gulf coast, and shows up in the fall in the North. It feeds on the leaves of corn, sugarcane, and sorghum, hiding in the throat of the plant. In the extreme South it does some damage but then largely disappears, doubtless being controlled by parasites. Arsenicals may be used against it if necessary.

INSECTS INJURIOUS TO THE STORED SEED

The seeds of sorghums are attacked by many of the insects that commonly infest stored grains. The more important of these are the rice weevil [21] and the Angoumois grain moth.[22] These two insects attack the seed in the field and continue their depredations after the seed is placed in storage. All of these seed-infesting insects can be controlled by a thorough fumigation with carbon disulphide. (See p. 33.)

[18] *Contarinia sorghicola* Coq.
[19] *Aphis maidis* Fitch.
[20] *Laphygma frugiperda* S. and A.
[21] *Sitophilus oryzae* L.
[22] *Sitotroga cerealella* Oliv.

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